# Quantification of scenarios for long-term economic and transport trends with ASTRA

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Abstract:

The System Dynamics Model ASTRA enables the assessment of long-term impacts of European economic and transport policies with respect to economic, environmental and social effects. It is enhanced to extend the coverage from the current EU member states to the CEEC. ASTRA is characterised by a composition of eight interacting modules with a macro-economics module in its centre. Besides this module there are further models picturing the development of population, transport, regional economics, foreign trade, environment and vehicle fleet and a module for welfare measurement. In the final paper results will be presented for economic and transport scenarios implemented in the model that e.g. could vary changes in taxation, labour productivity, consumption behaviour or trade patterns and that will be compared to a reference scenario. Indicators for the impacts of the selected scenarios will be e.g. GDP, employment or income for the enlarged EU to enable an analysis of economic influences of Accession.

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# 1 Introduction

As in the White Paper "European transport policy 2010: Time to decide" (CEC 2001) of the European Commission confirmed, transport plays an essential role for the functioning and growth of economy. Globalisation in economy is proceeding and networks are opening which implicates growing transport activities. Besides the economic benefits of increased transport flows within Europe the burden caused by growing transport activities has to be kept in mind. Therefore one major challenge for policy makers in the transport sector is to achieve economic growth in an environment-friendly way.

While in the current European Union Member Countries projected demand on energy caused by transport and $CO_2$ emissions are stagnating or growing slower than the world level the current situation in the EU candidate countries is different. Until the middle of the 1990s the already existing central environmental authorities in most of the Central and Eastern European countries had only low institutional capacities, small budgets and therefore a rather limited influence. This implies, together with the fact that environment-friendly transport equipment has been, before getting standard in these countries, nearly unaffordable, that the technical standards are not as sophisticated as in EU-15 countries. With the opening of markets for the candidate countries and the simplification of access in consequence of the accession to the European Union the transport activities coming from the CEE countries are increasing especially on the road mode. This implicates an enormous challenge for policy makers.

As in most transport policies the extension of transport infrastructure emerges one of the major topics and investments in infrastructure have long lead-times because realisation of infrastructure projects takes in some cases an entire decade policy makers rely on tools enabling projections of the impacts by their policies.

With the aim to generate such a tool enabling the assessment of long-term impacts of the European transport and economic policy with respect to economic, environmental and social effects the first version of the ASTRA model has been developed in the 4th FP of the European Commission by the Institute for Economic Policy Research (IWW), Karlsruhe, Trasporti e Territorio (TRT), Milan, Marcial Echenique & Partners (ME&P), Cambridge, and Centre for Economics and Business Research (CEBR), London, within the ASTRA project. ASTRA, which is the abbreviation for Assessment of Transport Strategies, is based on the System Dynamics Modelling method. Currently the existing ASTRA model is enhanced within the EU project LOTSE to extend the coverage from the current 15 EU member states to the twelve accession countries plus the EU-15 neighbour countries Norway and Switzerland.

The original purpose of this paper was to show a quantification of economic and transport policy scenarios for long-term trends. As there are many exogenous parameters that have to be filled up for the twelve accession countries plus Norway and Switzerland on the one hand for usage in calibration processes of ASTRA sub-modules and on the other hand to get the necessary exogenous influences to run the ASTRA model data collection was a long-term process. This process was hampered by the still insufficient data availability in most candidate countries. EUROSTAT e.g. provides in its Statistical yearbook on candidate countries main indicators but only on a very aggregated level. The OECD database (OECD 2003) offers more disaggregated data for example differentiated into industrial sectors but unfortunately not for all twelve accession countries (AC-12). To avoid losses in quality by transferring the existing model for the candidate countries on a significantly more aggregate level the available data had to be transformed into the needed disaggregated level. This procedure was mainly based on expert assumptions. In many cases for example the needed detailed data existed only on a rough level for several countries or even in the worst case no data was available. The assumptions that had to be done where mainly based on trends that could be observed in countries with a comparable transport and economic situation where the appropriate data was available.

The delay caused by prolonged data collection and generation process was mainly responsible for the project being still in its calibration phase. For this reason the paper concentrates mainly on the theoretical part of *System Dynamics (SD)* modelling, provides an overview on the different ASTRA modules with its specifications implemented to enable the spatial extension and its mode of function; furthermore it presents an outlook on the scenarios that might be feasible and finally it shows some transport and population trends that could already be calculated within independent sub-modules at this time. Final results for the economic and transport scenarios and the comparison with a business-as-usual scenario will be presented in the final paper the ECOMod oral presentation will be based on.

# 2 System Dynamics

To develop ASTRA-A the System Dynamics methodology and the System Dynamics standard software package Vensim 5.0 is applied. System Dynamics was developed during the 1960ies by FORRESTER (1962, 1977) at the Massachusetts Institute of Technology (MIT) to analyse the long-term behaviour of social systems like huge industries (General Electric) or cities (Boston). Forrester, who was an Electrical Engineer by education, applied the mathematical methods developed to analyse electric feedback control systems to social systems. He developed a graphical code, the mathematical foundations based on engineering approaches and the necessary software. In the end a theory and corresponding methodology was born that is based on:

- The theory of information feedback systems applied to social systems;
- The mathematics of differential analysis respectively difference equation analysis;
- Decision theory;
- An experimental model approach to the design of complex social systems;
- Digital computing for the vast amount of computation;
- A graphical scheme to represent systems of feedback loops.

Modern information feedback systems emerged at the beginning of the 20th century and by this time have been closely related to electrical systems like the first transcontinental phone lines in the United States and anti aircraft radar systems. Nevertheless, in the literature it is shown that they date back until three centuries before Christ when the first water clock flow regulators have been developed. All those systems have in common that they consist of at least one closed feedback loop in which a signal dependent upon the output of the system is fed back to the input of the system in such a way that it affects its own value. The mathematician Norbert Wiener in his book Cybernetics in 1948 has been the first to conclude that the feedback loop concept is a universal concept applying not only to mechanic and electric systems but also to humans and human systems. Forrester extended this conclusion by demonstrating that human systems including economy, society, technology and environment consist of a set of interacting feedback loops. Hence, he had to develop a theory and methodology that is able to model those interactions. One of the first steps was to develop a scheme to graphically present the interactions within a system of feedback loops: the so called effect diagrams. Based on these diagrams interdisciplinary teams could discuss and develop the structure of feedback loops in their analysed social systems. A subsequent step was to make use of the experiences gained by Electrical Engineers from analogue computers the so-called differential analysers. With these differential analysers a mathematical formulation was provided that enabled to describe a systems development over time. Forrester and his associates made use of this in developing software tools in the end using difference equations for calculating the dynamic equations of the feedback system and its development over time. To change from one state of the system to the next stage they applied decision rules. Finally, the developed software, called SIMPLE and DYNAMO in the beginning of System Dynamics, together with the ever increasing capabilities of digital computers provided the capabilities to follow an experimental modelling approach incorporating expert judgements and mental creativity, if no analytical or data-based solutions are available.

At IWW the System Dynamics methodology has been extended by System Dynamics Calibration Analysis, which is an approach that uses the optimisation capabilities of the applied Vensim software. With this analysis the whole model or parts of the model can be simulated and iteratively the relevant model parameters are altered until a certain statistical fit to real data is achieved or e.g. in case the model specifications would be misleading until a certain number of tests is performed without achieving the minimum statistical fit.

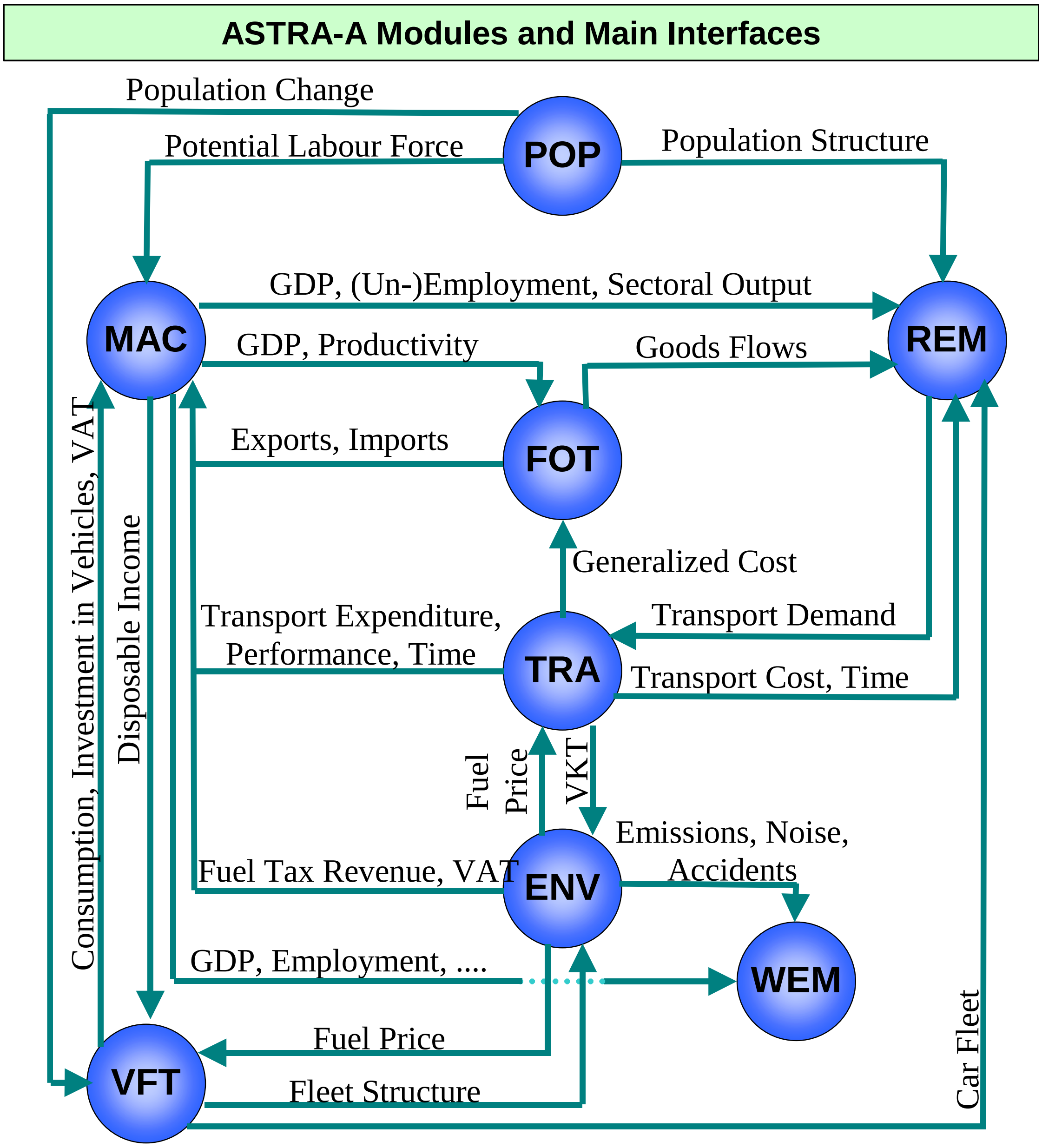
Additionally to the theory of System Dynamics, each module is based on specific theories related to the purpose of the module. For instance the macroeconomics module integrates neo-classical production functions with Keynesian consumption and investment behaviour and with elements of endogenous growth theory to incorporate technological progress.

# 3 Integrated Overview on ASTRA-A

The following subchapters provide an overview on the ASTRA model. For more detailed information TIPMAC D3 should be considered (SCHADE et al. 2002). The ASTRA model consists of eight modules that are all implemented within one Vensim 5.0 System Dynamics software file that is running on the Windows XP platform. The eight modules are:

- Population Module (POP),
- Macro-economic Module (MAC),
- Regional Economic Module (REM),
- Foreign Trade Module (FOT),
- Transport Module (TRA),
- Environment Module (ENV),
- Vehicle Fleet Module (VFT) and
- Welfare Measurement Module (WEM).

Figure 1 shows the interrelationships between the eight ASTRA modules. It pictures the major output variables coming from and input variables going into the modules. As in section 3.7 alluded the only difference to the mode of function presented in this figure exists for the vehicle fleet module of the twelve candidate countries. In contrast to the EU-15 car, bus and truck fleet the structure of the AC fleet was calculated exogenously.




Abbreviations:

| | |
|---|---|
| **POP = Population Module** | **TRA = Transport Module** |
| **MAC = Macroeconomics Module** | **ENV = Environment Module** |
| **REM = Regional Economics Module** | **VFT = Vehicle Fleet Module** |
| **FOT = Foreign Trade Module** | **WEM = Welfare Measurement Module** |

***Figure 1: Overview on the structure of the ASTRA-A modules***

## *3.1 Population Module (POP)*

The Population Module (POP) provides the population development for the EU-15 as well as for the candidate countries with one-year age cohorts. The model depends on exogenous factors like:

- fertility rates,
- death rates,

- infant mortality rates and
- migration into the 29 modelled European countries.

Based on the age structure given by the one-year-age cohorts important information is provided for other modules like the number of persons in the working age or the number of persons in age classes that permit to acquire a driving licence. The POP is calibrated to the TIPMAC population forecast that is taken from EUROSTAT baseline population predictions until 2050 (PONTI et al 2002). Because of significantly higher infant mortality and death rates noticed in the 1990s in the Central and Eastern European countries, e.g. Romania has a more than four times higher infant mortality rate than Germany, the existing EU-15 population model had to be adjusted to meet the EUROSTAT population forecasts also for CEE countries. A factor representing improvements in health care reducing infant mortality and increasing life expectancy via reduction of death rates had to be implemented which can be justified by the undoubted fact of growing economic welfare going hand in hand with technical progress and better medical care.

## *3.2 Macro-economic Module (MAC)*

The MAC provides the national economic framework in which the other modules are embedded. The MAC can not be categorised explicitly into only one economic category of models for instance a neo-classic model. Instead it incorporates neo-classical elements like production functions but also Keynesian elements like the dependency of investments on consumption. These have been extended according to the requirements of the ASTRA objectives e.g. such that investments are also made dependent on exports. Four major elements constitute the functionality of the macro-economics module.

**1. Sectoral interchange model**

The sectoral interchange model reflects the economic interactions between 25 economic sectors of the national economies by an Input-Output table structure. The structure of 25 economic sectors is based on the NACE-CLIO system established by EUROSTAT for input-output data. The input-output tables are driven by changes of final demand. The structure of the tables can either change due to shifts between sectors of final demand and due to changes in transport costs that are part of the intermediate inputs in the input-output table. The main output taken from the input-output model are the sectoral production value (total output) and the sectoral gross value added.

**2. Demand side model**

The second element, the demand side model depicts the four major components of final demand:

- consumption,
- investments,
- exports-imports (which is modelled in detail in the foreign trade module) and
- the government consumption.

**3. Supply side model**

The basic element of the supply side is a production function of Cobb-Douglas type calculating potential output that incorporates the three major production factors labour supply, capital stock and natural resources as well as technical progress referred to as total factor productivity (TFP) Total factor productivity is endogenised depending on sectoral investments, freight transport time-savings and labour productivity changes.

## 4. Micro-macro bridges

The fourth element constituting the MAC are the micro-macro bridges. These link micro- and meso-level models for instance the transport module or the vehicle fleet module into parts of the macro-economic module (see Figure 2). That means, for instance, that private expenditures for bus transport or rail transport become part of the final demand of the economic sector for inland transport within the sectoral interchange model.

The macro-economic module provides several important outputs to other modules. The most important one is, for sure, *Gross Domestic Product (GDP*). This is for instance needed as one driver to generate the domestic freight flows within the Regional Economics Module (REM). *Labour productivity* is part of the factors that are driving the foreign trade module. And finally *disposable income per adult* is the driver of car purchase influencing the EU-15 vehicle fleet module.

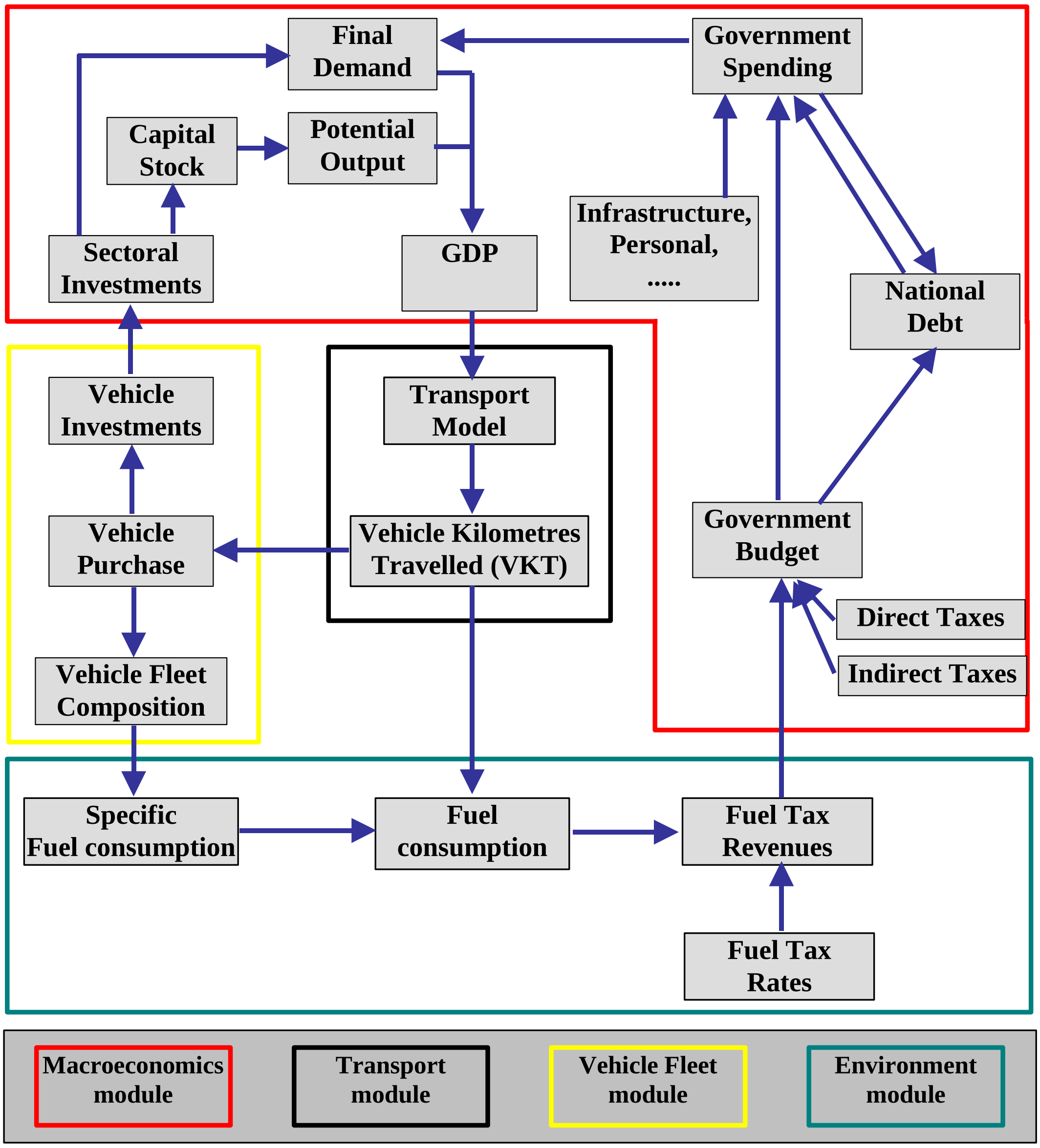



*Figure 2: Examples for outputs of MAC and micro-macro-bridges to MAC*

## 3.3 Regional Economics Module (REM)

The Regional Economic Module (REM) mainly provides the generation of freight transport volume and passenger trips.

The number of passenger trips is driven by

- the employment situation,
- the car-ownership situation and
- the number of people belonging to different age classes.

Trip generation is performed individually for each of the 75 functional zones implemented in the ASTRA model. Each of the EU-15 countries is subdivided into four zones composed of groups of homogenous NUTS-II zones. The functional zones were identified by analysis of settlement patterns and GDP per capita. Due to the country size and the results of the settlement and GDP/capita analysis the accession countries were only subdivided into two respectively one functional zone for the small countries like Cyprus, the Baltics, Malta and Slovenia. Domestic freight transport depends on sectoral output that is transferred into flows for the fifteen sectors, which produce goods, by means of value-to-volume ratios that are derived from the SCENES model. International freight transport is derived from the sectoral trade flows that are output of the foreign trade module. For freight distribution and the further calculations in the transport module the demand volumes of the fifteen sectors are aggregated into three goods categories: bulk goods, general cargo goods and unitised goods.

## 3.4 Foreign Trade Module (FOT)

The foreign trade module (FOT) is subdivided into an INTRA-EU-27 and an EU-27 to rest-of-the-world countries model. Switzerland and Norway as neighbour countries of the European Union were assigned to EU-27. The rest-of-the-world countries were aggregated into nine regions, which are: NAFTA, Latin and Middle America, Japan, China, India (India + Pakistan + some smaller countries), East Asean Tigers (e.g. South Korea, Thailand, Malaysia), Oceania (mainly Australia + New Zealand), Turkey, Rest-of-the-world. A description of the EU-RoW trade model can be found in SCHADE/SCHAFFER/KOWALSKI (2002) or SCHADE/KRAIL (2003).

Both, INTRA-EU and EU-RoW model, are mainly driven by relative productivity between the European countries (EU-15 and accession countries) or between the European countries and the rest-of-the-world countries, GDP growth of the importing country and world GDP growth as an external factors to trade. Additionally the INTRA-EU-27 trade flows depend on the averaged generalized cost of transport between each of the country pairs of the EU-27. The resulting export-import flows of these two trade models then are fed back into the macroeconomics module as part of the final demand. Secondly, the INTRA-EU-27 trade model provides information for freight generation to the REM module.

## 3.5 Transport Module (TRA)

The major input of the Transport Module (TRA) is the link based transport demand for passenger and freight transport. Using transport costs and transport time matrices the transport module is calculating the modal split based on the classical 4-stage transport model applying logit-functions depending on generalised costs e.g. to calculate the modal-split (ORTUZAR/WILLUMSEN 1998). National transport is modelled with the classical 4-stage transport model consisting of generation, distribution, modal-split and a rough modal capacity models. In contrast to national freight transport the first two stages of the international freight transport, generation and distribution, are replaced by input from the export model, which provides sectoral goods flows in monetary terms that are then converted with volume-to-value ratios into three types of goods flows between countries and zones that then feed into international modal split for each OD-pair. In the final stage all flows are assigned to domestic networks to model capacity limitations and time reactions of the various modes.

Passenger and freight transport are subdivided into five respective four distance band covering local, regional, medium and long distances. Cost and time matrices depend on influencing factors like infrastructure investments, fuel price or fuel tax changes. For road transport also network loads are considered for several different road types such that congestion effects may affect the road transport time matrices. For the other modes also rough capacity constraint functions have been developed. Depending on the modal choices transport expenditures are calculated and provided to the macro-economic module. Changes in transport times are also transferred to the macro-economic module such that they provide an input to *Total Factor Productivity*.

## 3.6 Environmental Module (ENV)

The major input for the Environment module (ENV) are the vehicle-kilometres-travelled (VKT) generated by the TRA module per mode and per distance band respectively traffic situation. Based on these traffic flows and the information from the vehicle fleet model on the vehicle fleet compositions and hence on the emission characteristics, the environmental module is calculating the emissions from transport. Besides the emissions also fuel consumption and fuel tax revenues from transport are estimated by the ENV. Traffic flows and accident rates for each mode form the input to calculate the number of accidents in the European countries. The expenditures for fuel, the revenues from fuel taxes and value-added-tax (VAT) on fuel consumption are transferred to the macro-economic module and provide input to the economic sectors covering fuel products and the government revenues (see Figure 3).

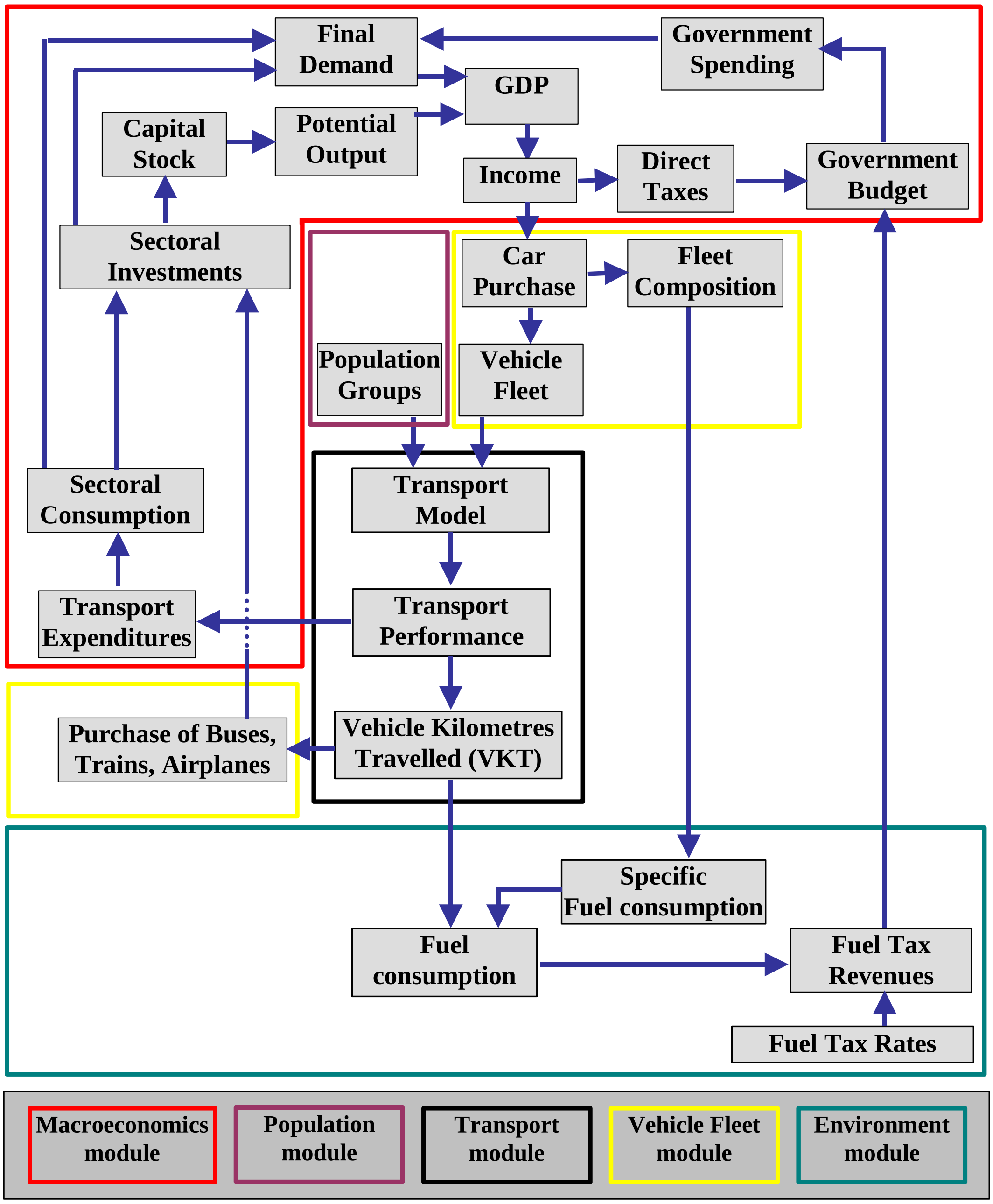



*Figure 3: Macro-economic inputs, transport results, tax revenues and budget implications*

## 3.7 Vehicle Fleet Module (VFT)

The Vehicle Fleet Module (VFT) is calculating the vehicle fleet composition for all road modes for the EU-15 countries. Vehicle fleets are differentiated into different age classes based on one-year-age cohorts and into different emission standard categories. Additionally, the car vehicle fleet is differentiated into gasoline and diesel powered cars with different cubic capacity categories. The car vehicle fleet is developing according to the income changes, the development of population and the development of the fuel prices. The vehicle fleet composition of bus, light-duty vehicles and heavy-duty vehicles mainly depends on the driven kilometres and the development of average annual mileages per vehicle of these modes. The purchase of vehicles is translated into value terms and forms an input of the economic sectors in the MAC that cover the vehicle production. The EU-15 vehicle fleet models consider also scrapping of a certain share of vehicles during the average life time.

In contrast to the endogenously modelled EU-15 vehicle fleet, CEEC vehicle fleets are generated exogenously. The CEEC car fleets are calculated based on projections derived from the POLES model of IPTS, Seville. The projections containing total values for registrations per mode of drive and total numbers of car fleet were combined with information on the distribution of cubic capacity categories differentiated into gasoline and diesel powered cars provided by the CZECH TRANSPORT YEARBOOK 2001. To calculate the car fleets further disaggregated into emission categories the point of time of emission standards' introduction has been adjusted to the times that were applied in the EU-15 countries assuming that, before the accession, the introduction of emission standards was delayed by on average 3 years. The delay in introduction of EURO 1 and EURO 2 was estimated because of remaining car production of Eastern European car brands with lower standards until the late 1990s. The point of time of introduction of EURO 3 emission standard was assumed to be similar in EU-15 and CEE countries.

### *3.8 Welfare Measurement Module (WEM)*

Finally in the Welfare Measurement Module (WEM) major macro-economic, environmental and social indicators can be compared and analysed. Policy changes as percentages to a reference scenario are provided by the WEM. Different assessment schemes that combine the indicators into aggregated welfare indicators for instance an investment multiplier or a CBA ratio are offered. However, due to the model size the CBA ratio is not anymore calculated "online" with the scenario calculations.

# 4 Calibration of Modules

The calibration of a complex, large scale System Dynamics model like ASTRA is a stepwise process as it is not possible to calibrate it all at once with the full model. In the first step major variables like GDP are fixed to exogenously given data during the calibration period 1990 to 2000. This means that the feedbacks from the rest of the model on these variables are cut off and the model behaves as if the inputs to these variables would generate the data. In a sense at this stage one could distinguish dependent and independent variables like GDP. However, this distinction could not be made when the feedback loops are closed and "*everything depends on everything else*". Then the parameters of the model are adjusted either in an ad hoc manner if only other parameters have been changed or, if structural changes are implemented, adjustments have to reflect the new structure, such that in both cases an initial solution is found without generating any chaotic behaviour.

In the second step still major variables are kept fixed but now variables of minor importance are calibrated to data. In the third step the major variables like investment or GDP are calibrated to data. Finally, the model is checked with all feedback loops closed and if necessary further adjustments of parameters are made. Usually, the second, third and final step are applied in an iterative process. In general a specific sequence of models is followed that depends on the degree of interaction and the availability and quality of data that is required for calibration of the specific model. Models with a lower degree of interaction e.g. only one or two endogenous inputs are calibrated earlier compared with models with many endogenous inputs. The POP module for example is a model that depends not on inputs of other ASTRA modules. Another module with only few endogenous inputs is for example the TRA module. Models with good data availability and quality can also be calibrated earlier compared with models for which the "input data" for calibration has to be provided by the ASTRA model itself as exogenous data is not existing. For specific models so-called stand-alones are developed that can be calibrated separately outside the full ASTRA model.

There are different calibration approaches applied in the LOTSE project. As far as possible automatic calibration tools are used. The first option is the optimiser tool of the Vensim software, which is the standard System Dynamics software package used for the implementation of ASTRA. Tools have been developed that in combination with the Vensim optimiser enable to calibrate matrices with large numbers of countries, sectors or zones. This optimising process shows similarities to econometrics as in principle R-squares could be computed to provide statements on statistical fit. Nevertheless it is not the major purpose of calibration of a System Dynamics model, which is different to econometrics as the statistical measures are not the only thing that counts for a good calibration, since reasons like bad data quality or missing data reduce the meaning of statistical fit to "data" and increase the importance of plausibility checks of dynamic model reactions to reality and sensitivity analysis which are both used in System Dynamics. With these tools either stand-alone parts of the ASTRA model are calibrated or at later stages of the calibration process the whole model would be optimised. However, in some cases also expert calibrations are needed as for instance no reasonable extraction of a stand-alone model is feasible because of too many endogenous influences. Stand-alone calibrations with Vensim are developed for the population model, all road vehicle fleet models, car-ownership, input-output model, export model, capital stock, national income, total employment, investment and potential output in conjunction with GDP. Furthermore calibration procedures for the logit-equations in the transport model are developed based on computations with a Microsoft Access database.

The process of calibration takes place nearly in the same manner for EU-15 and CEE countries. The only difference is that the models are calibrated separately for EU-15 and CEE countries because of varying calibration periods. The modules’ calibration for CEE countries allude to the period from 1995 to 2000. This deviation from the original approach was made necessary because of the unstable economic situation in the CEE countries within the first 5 years after the communist systems’ collapse in the late 1980s. Besides the problems of reliable historical data further barriers were the lack of data for this period for some CEE countries and for example for Romania and Bulgaria enormous deviations for main economic indicators in several statistical databases caused by high inflation rates and different exchange rates from national currency into the standard ASTRA monetary unit EURO 1995.

# 5 Policy and Technological Scenarios

This chapter should give an idea on feasible scenarios which will be compared with a business-as-usual scenario in the oral presentation. As the project is currently in its modelling phase for the reference scenario, policy and technological scenarios are not yet determined. For this reason the presented scenarios reflect only ideas and might vary in their specification in the final presentation. Possible policy and technological scenarios could cover economic, transport, social or environmental topics.

Main issues in transport related scenarios would be on the one hand policy scenarios or on the other hand technological scenarios. Feasible and interesting policy scenarios could take into account changes like regulation, vehicle taxation, implementation of road pricing or various oil price trends for EU-15 as well as for CEE countries. The level of individual road pricing might be affected by vehicle emission standards, number of axles or maximum weight. For example a metropolitan charging scenario like it was introduced in London and a scenario changing the occupancy rates respectively load factors are planned to be analysed. Technological scenarios could be characterised by an addition of new vehicle categories, improvements in logistics, changing fuel efficiencies or emission standards. It is planned to introduce new vehicle categories for example cars with fuel cells or hydrogen drives into the vehicle fleet module as reaction on projected loss of fossil fuels.

Economic scenarios could vary changes in direct and indirect taxation, labour productivity, consumption behaviour or trade patterns. In context with labour productivity a scenario investigating the impacts of different speed of technical progress in the Candidate countries might be interesting. The inclusion of the accession countries will enable analysis of influences of accession of candidate countries to the European Union. Impacts of variations in demographic parameters like population caused by changes in migration, fertility or death rates could be analysed via societal scenarios. Especially the impacts of changes in migration might be interesting because of economic growth going hand in hand with increasing attractiveness of migration into CEE countries. At last environmental scenarios would consider changes caused by regulation of fuel consumption or $CO_2$ emissions related to the Kyoto Protocol. A conceivable scenario could be the introduction of a carbon tax per ton of $CO_2$ emission. Combinations of presented scenarios are also conceivable and might be reasonable for example as increasing revenues should be refunded for example via reduced direct taxes or vehicle-related taxes.

Figure 4 shows the major impulses given by policy scenarios like introduction of road pricing and every other pricing scenario. The scheme fits also for scenarios including additional investments for example in infrastructure. The only difference would be a direct positive impact on transport times. Each chain starts with the pricing scenario implementation on the left and ends with change of GDP on the right. However, each chain follows different time structures such that in some cases the impacts of the chosen pricing policy immediately affects GDP. ASTRA performs calculations on a quarterly base. In that sense, immediately could mean in the same quarter or in the subsequent quarter depending on the structure of equations. In other impact chains it takes up to 5 years until the bulk of impacts is reaching GDP. In the figure it is also indicated that there are interactions between different impact chains. And GDP changes feed back into the chains e.g. to income or exports. Nevertheless, the figure shows only a selection of important chains that is by far not exhaustive.

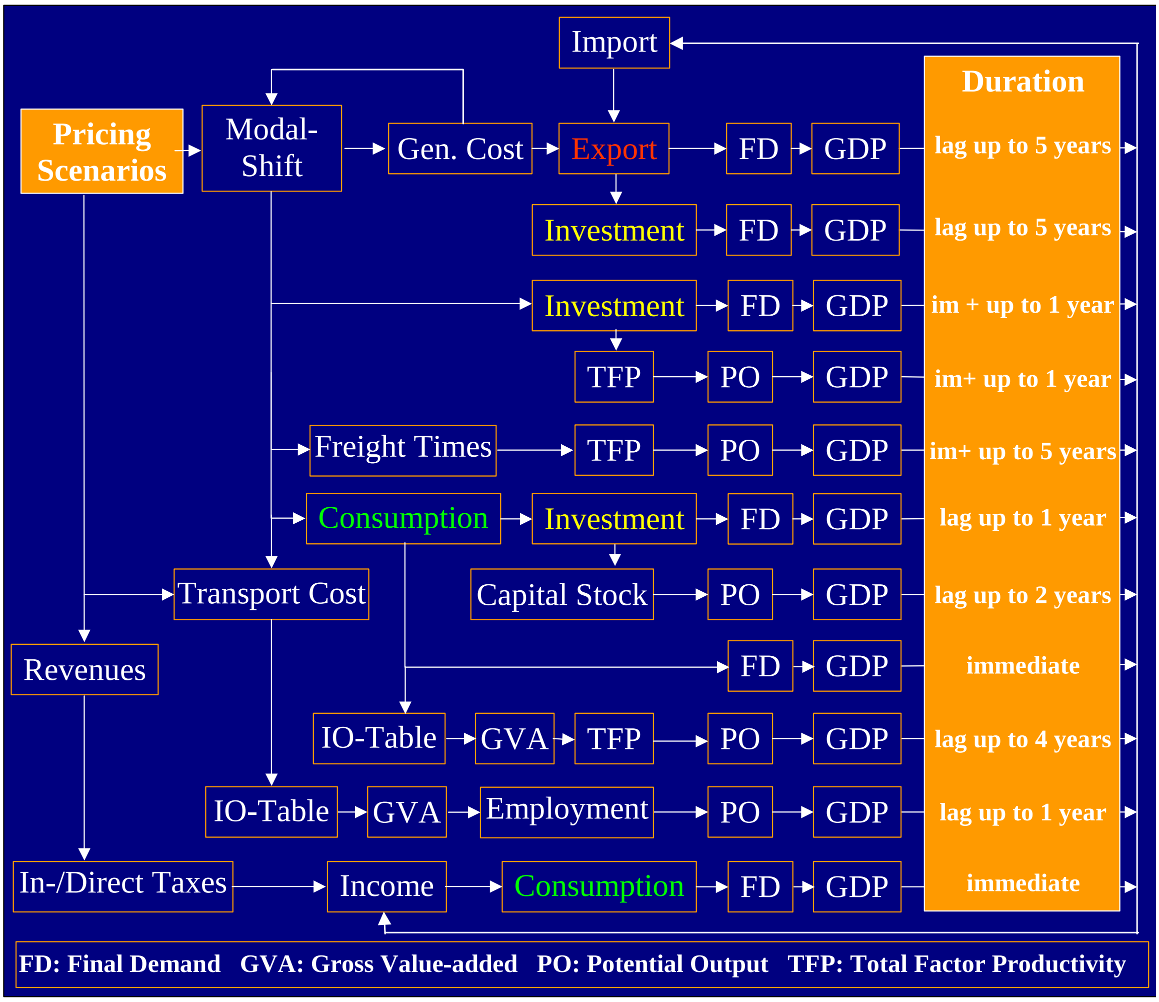



***Figure 4: Impact chains and their time structure kicked off by Pricing Scenarios***

# 6 Preliminary Results

The following section presents transport trends for the candidate countries and preliminary results of the business-as-usual scenario for population and transport trends in EU-27 from already finished and calibrated stand-alone models. The results of the Population (POP) model are levelled of in the business-as-usual scenario of the final model because this model constitutes independent from other ASTRA modules. Results for the Transport (TRA) stand-alone model might change because of dependency on indicators of other modules like for example Intra-EU-27 exports influencing freight transport distribution.
As the MAC module is not yet calibrated no preliminary data can be presented at this point of time.

## *6.1 Development of Population*

The results depicted in Figure 5 stress the differences as well as the similarities in development of total population, number of children, persons from 16 to 64 and persons in retirement between EU-15 and AC-12. While total EU-15 population slightly increases within the period from 1990 to 2020 with a stagnation in the last five years, AC-12 population shows a decrease over the time period that is getting stronger until 2020. The visible decline of births within EU-15 countries is exceeded significantly by the decrease that can be seen in the growth rates for number of children younger than 16 years in AC-12 countries. A loss of birth rates in AC-12 after the political systems’ change in the 1990s was observed which could not be levelled by improvements of health care reducing infant mortality rates within the time period from 1990 to 2000 up to a level of 50 %. Regarding the structural changes within AC-12 it has to be kept in mind that AC-12 fertility rates at the beginning of the 1990s were on average 25 % higher than the rates in EU-15 countries.

Besides the trend at total number of children there is an opposite development at total number of persons in retirement visible. Once again the EU-15 trend is topped by the increase of retired persons in AC-12 countries. From 2010 onwards the AC-12 growth rates are three times as high than for EU-15 countries. This is mainly influenced by the changes in cohort structures but also by decreasing death rates caused by definite improvements in medical care systems.

The development of potential labour force in AC-12 is similar to the trend in EU-15 countries. A slight growth from about 0.4 to 0.9 % can be observed until 2010. Afterwards the irruption in birth rates from 1990s are reflected in a decreasing number of persons in working age.

The final transport and economic results presented in the oral presentation will show the macro-economic influence of observed structural changes in demography. Undoubtedly the structural changes in demography with more and more persons in retirement in EU-15 and especially in AC-12 means a further strain on these economies because additional expenditures of the state demand for higher revenues.

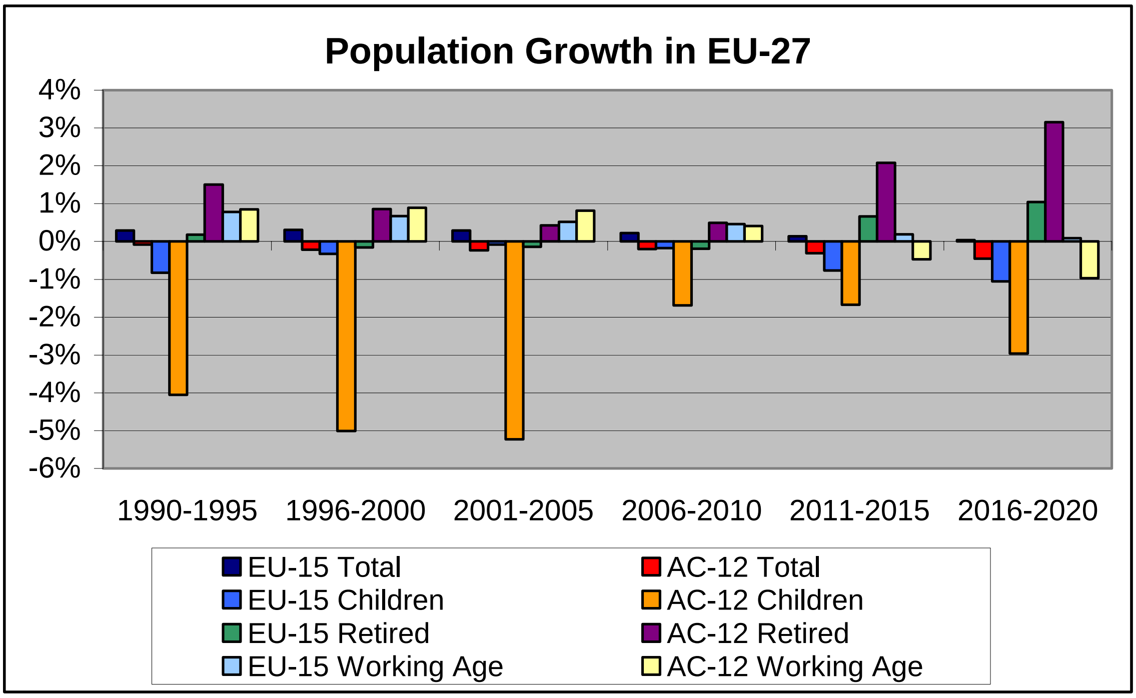



***Figure 5: Average annual population and cohort growth rates in EU-27***

## 6.2 Development of Transport

An overview on the infrastructure and transport situation in the CEE countries in the 1990s will introduce the ASTRA passenger and freight transport trends. Before the collapse of the communist respective socialist systems in the CEE countries in the late 1980s the railway network was extended to a density of on average 7.5 km / 100 km$^2$ (EU-15: 6.2 km / 100 km$^2$) (BURNEWICZ 2000). The sufficient density of the CEEC railway network belies the condition and the type of railway tracks. Characteristic for the railway network is a lack of fast railway tracks, quality and comfort of passenger trains not being adequate to EU-15 level and a low share of railway lines with single and double tracks. The status of the road network in CEE countries is by far worse. Though the density of the CEEC road network is similar to the EU-15 one, the condition of roads is because of negligence of maintenance and the application of poor-quality materials rather poor and similar to the railway network the shares of motorways and expressways of the total network are still low. The present structure of transport network in the CEE countries is largely the inheritance of the former political systems concentrating on its basic needs, to support industries like heavy mining and therefore to construct an infrastructure enabling transport of large quantities of mainly bulk goods. The former status of time factor caused by the economic and political systems in CEE countries is also reflected in road and rail network with only low shares of high-speed tracks.

After the systems' change in CEE countries the transport sector had and still has to manage challenging modifications. This process of getting privatised, more efficient, better equipped with better quality of staff and, as result, being competitive on the international market has been supported by financial help of private investors who recognized investments in transport sector being more profitable than infrastructure investment for example in construction of tolled roads. This results in the consequence that necessary infrastructure investments have to be financed by the states. In connection with the forthcoming accession of the CEE countries the process of realisation of EU plans for the creation of a uniform transport infrastructure were realised. This implies beneath qualitative improvements and modernisation of the existing road and railway network the construction of a trans-European network which is because of better accessibility for growing transit traffic in EU-15 and CEE countries by mutual interest. The so-called TEN (trans-European transport networks) and especially the TINA (Transport Infrastructure Needs Assessment) (NEA et al. 1999) infrastructure projects covering CEE countries launched by the European Commission contain the planned infrastructure measures with a total costs of more than 300 Billion Euro until the year 2020 (TEN-STAC 2003).

Figure 6 and Figure 7 depict ASTRA results on passenger and freight transport trends of the stand-alone model. As mentioned above the results were generated in a stand-alone model that implies the influences of the planned TEN and TINA infrastructure projects on transport times for road and rail mode. The input for the ASTRA transport model like for example transport times was provided by the VACLAV network model. Figure 6 shows average annual growth rates of passenger kilometres for periods of five years differentiated into the four origin-destination categories Intra-AC, Intra-EU, AC to EU and EU to AC for road and rail mode. Intra means in this context transport between the ten accession or between the fifteen EU countries. The most eye-catching category pictured in this figure is the dominating growth rate of Intra-AC passenger-km for road mode with on average 5.4 % up to 9.6 % annual growth in the period from 2000 to 2020. The high annual growth rates for passenger-km within CEE countries reflect the improving economic situation going hand in hand with higher disposable income. Numbers and forecasts for registration of new cars until 2010 confirm the presented trend to more individual mobility by increasing car-ownership in CEE countries. This trend is additionally enforced by investments in road infrastructure. The significant trend to a changed modal split to the benefit of road mode in Intra-AC passenger transport is completed by small growth rates for passenger transport on railways with less than 1 %. The modal shares of Intra-AC passenger transport by railways shifts from 25 % in the base year to less than 10 % in the year 2020. Looking at this figures the modal split situation in the beginning of the 1990s with significantly higher shares of passenger transport by railways than in EU-15 countries has to be kept in mind.

Looking at the growth rates of Intra-EU passenger-km on road and rail a scheme contradictory to the Intra-AC one is illustrated by the ASTRA results. Train passenger-km are increasing significantly higher with at minimum 2.5 % up to 3.6 % than road passenger-km with on average less than 1 %. This change might be caused by a combination of better supply with more and more high-speed railway lines, increasing fuel prices and total running costs for cars and changes in transport times influenced on road in a negative way by congestion and on rail in a positive way by new and faster lines.

The categories of passenger transport performance AC-10 to EU-15 countries as well as the opposite direction provide a similar picture with moderate growth rates and only slight differences between road and rail mode. The rates range between 0.7 % and 1.2 % for road mode in both directions respectively between 0.9 % and 1.6 % for rail mode also in both directions.

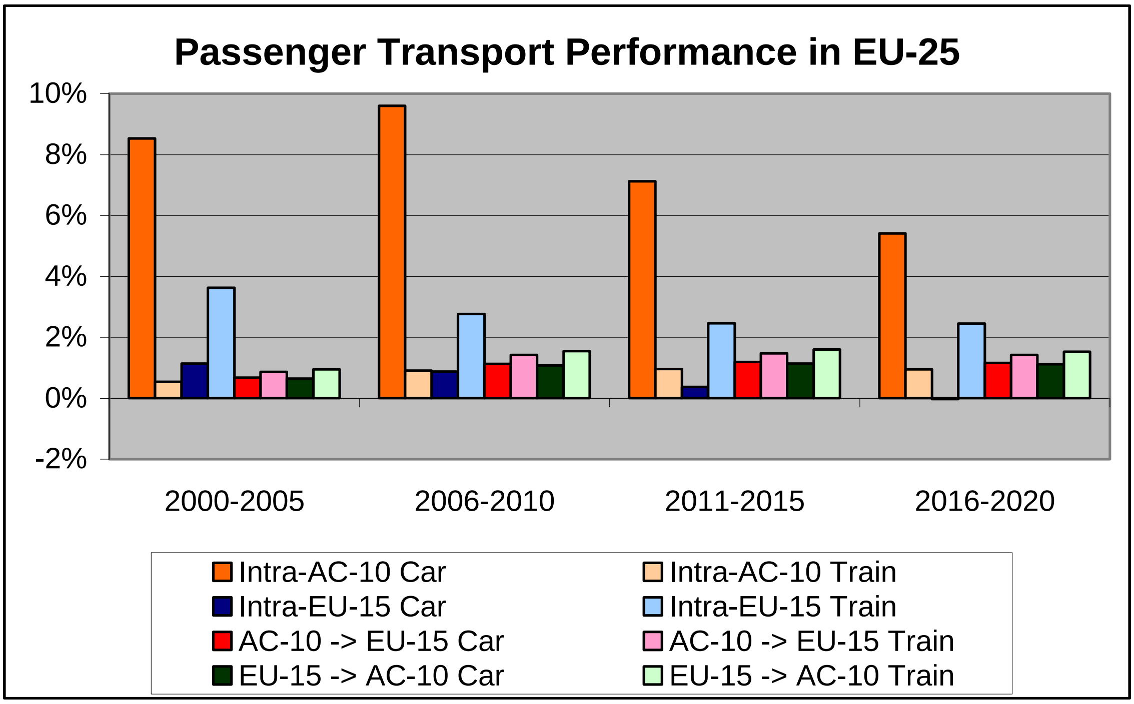



***Figure 6: Average annual passenger-km growth rates in EU-25***

Figure 7 offers an overview on EU-15 and AC-10 transport performance with ton-kilometre growth rates in periods of five years subdivided in the same categories applied in the previous figure for passenger transport. As expected transported ton-km on road show for each category higher growth rates than for rail mode. Nevertheless ton-km on railways are except for Intra-AC significantly increasing. The positive reactions of the accession of the candidate countries to the European Union planned in 2004 and 2007 on transit traffic level show the definite increases of growth rates in the period from 2006 to 2010. As in chapter 3.5 mentioned international transport is directly influenced by exports (SCHADE 2004). The accession of the CEE countries to the EU together with the construction of a pan-European network will abolish trade barriers and is reflected in stronger growing freight transport between the future EU-27 countries. Similar to the situation at passenger transport the Intra-AC rail ton-km are only slightly increasing with on average 0.4 % causing in combination with growth rates for ton-km on road mode from 3.2 % up to 4.5 % a noticeable modal split change from rail to road mode in the accession Countries.

The average annual growth rates for Intra-EU ton-km on road and rail range between 3 % and 4.9 % respectively between 2.1 % and 3.3 %, AC to EU ton-km between 2.8 % and 4.1 % for road mode respectively between 1.8 % and 2.9 % for rail mode and EU to AC ton-km between 2.6 % and 3.9 % for road mode respectively between 1.9 % and 3 % for rail mode.

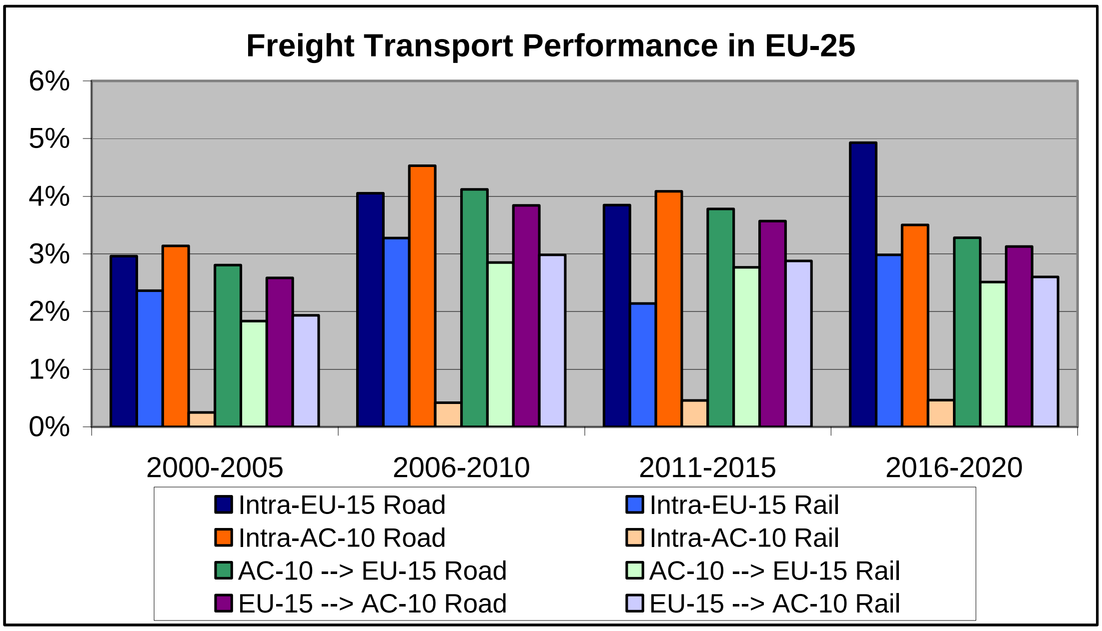



*Figure 7: Average annual ton-km growth rates in EU-25*

# 7 Conclusions

The System Dynamics approach applied in ASTRA provides an excellent platform to policy and technological scenario analysis. Model results can be analysed by with-and-without tracing and by implementing policy variants that follow European transport policy strategies. With-and-without tracing means to switch off a single mechanism or a set of mechanisms during a model simulation. The resulting difference between a basic run (with) and the run excluding a mechanism (without) can be assigned as impact of the excluded mechanism. Unfortunately final results comparing scenarios with a business-as-usual scenario could not yet be presented in this paper but will be handed in the paper the oral presentation at ECOMod conference 2004 will be based on.

Nevertheless the paper provides an overview on the mode of function of the ASTRA model, its features and its necessary specifications enabling the enlargement of the model to cover the future EU-27 countries plus Switzerland and Norway. The model represents an integrated dynamic approach to describe the interactions between transport and the economy over time and space to analyse the impacts of the European transport and economic policy. Feasible economic, transport, social and environmental scenarios were described and population and transport trends derived from yet existing ASTRA stand-alone models shown. Taking into account the forthcoming Accession of CEEC to the EU the model results for the presented feasible scenarios will provide a valuable cognition on how to integrate most efficient the eastern European national economies in context with sustainable development.

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